CIE Reviewer's Report on the Panel Review of the Collaborative Optical–Acoustic Survey Technique (COAST) for Surveying Rockfishes

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Prepared for:

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Executive Summary

The review of the Collaborative Optical-Acoustic Survey Technique (COAST) developed by the Southwest Fisheries Science Center (SWFSC) for estimating the abundances and distributions of rockfishes, and mapping their seabed habitats, was conducted by a Methodology Review Panel, at the SWFSC Torrey Pines Court Laboratory, La Jolla, CA, from 15-17 February 2012. The main objectives of the review were to review the methodology, evaluate the analytical procedures, identify areas of uncertainty, and provide guidance/ recommendations on the use of the approach in the assessment of rockfish species, primarily in the Southern California Bight.

All background material necessary to conduct the Panel Review was made available almost two weeks in advance, allowing plenty of time to prepare for the meeting. In general, the Panel review adhered to the agenda provided to Panel members prior to the meeting, although the Chair was flexible and allowed diversion into other subject areas when they were relevant to the discussion. Several Panel requests for additional information or clarification of procedures were made to the technical team. These requests were fulfilled promptly and to the satisfaction of the Panel. Much of the success of the Panel Review can be attributed to the technical team who did an excellent job of summarizing the information and providing the available data to address the issues at hand. The Chair kept the group focused on the topic being discussed while at the same time allowing everyone, including observers, to express their views or contribute their expert opinion. A number of the attendees also provided valuable input during the course of the meeting.

The COAST method combines two independent sampling approaches, acoustic and optical surveys, to estimate the biomass of multiple species in mixed rockfish assemblages. The method merges sampling data with little if any spatial overlap, and in some cases no temporal overlap, to apportion the acoustic backscatter into the species composition observed in the optical survey. In doing so a number of assumptions are made regarding the distribution of rockfish in the water column, their behavior in the presence of a submerged scientific platform, and the representative nature of the species composition in the relative narrow observation window of the optical survey.

The fundamental assumption that the optical survey observed rockfish species proportions were a good proxy for the water column composition and that they provided an unbiased representation of the vertical distribution is critical to the COAST approach. This assumption is likely the most critical and the most contentious issue in merging the two survey approaches under the COAST program to estimate biomass for numerous rockfish throughout the Southern California Bight. Other issues such as spatial coverage of the surveys, target

strength, fish size, fidelity, sampling frequency, acoustic dead zone, analytical procedures, and error estimates were reviewed and discussed.

The COAST approach has the potential to be utilized as a standalone method for quantifying rockfish biomass in the SCB and as an index of abundance for stock assessment models over a broader scale distribution. In addition, the method could be used to monitor the status of specific banks of interest to evaluate the effects of management actions over time. However, at the moment there are a number of unresolved problems and major sources uncertainties outstanding that need to be addressed. These include: (i) complications associated with species diversity and the subsequent estimation of species proportions; (ii) equal detectability of species in the acoustic detectable field; (iii) equal distribution of fish species in the ROV view; and (iv) equal avoidance behavior for all species.

Ultimately, it is likely that the COAST approach will be found to be appropriate for the assessment of some rockfish species, questionable for some species, and inappropriate for other species – which species fall into each of these categories has yet to be defined.

The Panel's summary report was not available at the time the CIE report was submitted. This CIE document represents an overview of the Panel discussions and reflects the general consensus view of the Methods Review Panel. I fully concur with content, recommendations, and conclusions contained in the draft Panel Report prepared prior to the meeting's close.

1.0 BACKGROUND

The National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center, La Jolla, CA, developed the The Collaborative Optical-Acoustic Survey Technique (COAST) for estimating the abundances and distributions of rockfishes, and mapping their seabed habitats. In 2003, 2004/5, and 2007/8, the Fisheries Resource Division (FRD) conducted COAST surveys, in collaboration with the Sportfishing Association of California (SAC), to estimate the distributions and abundances of rockfish, by species, throughout the SCB. The primary purpose of the survey approach was to improve assessments of multiple rockfish species; investigate the relationships between rockfishes and environmental factors; and scientifically evaluate the effectiveness of the Cowcod Conservation Area (CCA) and other management strategies. As part of the ongoing process, a five-person methodology review panel was established, including three Center for Independent Experts (CIE) reviewers, to evaluate the COAST methodology. The review meeting held at the SWFSC Torrey Pines Court Laboratory, La Jolla, CA, from 15-17 February 2012.

The COAST approach utilizes historical catches from the sports fishery and fishing Captains and habitat information to initially define survey areas; data from ship-based multi-frequency echo-sounders to map the acoustic backscatter from rockfishes in these survey sites; and, video and still images from cameras deployed on a remotely operated vehicles (ROV) to quantify the proportions of rockfish species, and their size-distribution, in acoustically-detected mixed assemblages. The optical information is then used to apportion the rockfish backscatter into species, calculate their length-dependent target strengths, and estimate and map the biomass of individual species. Optical sampling is not restricted to ROVs and could be obtained using other camera platforms, e.g., submarines or autonomous underwater vehicles.

The purpose of the panel review is to evaluate the COAST methodology and to prepare a Summary Report that will be used to guide improvements to the COAST survey and analytical methods, the time series of estimated rockfish abundance and distribution, and the estimates of uncertainty. The method while designed for rockfish could be used to survey other demersal fishes along the California coast and north. Consideration by the stock assessment analysts will be given to the conclusions and recommendations of the Panel Report, but Stock Assessment Review (STAR) Panels will review the assessment models.

The National Marine Fisheries Service (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise, through the Center for Independent Experts (CIE), to conduct independent peer-reviews of NMFS scientific projects. The CIE reviewers are selected by the CIE Steering Committee and the CIE Coordination Team to conduct the independent peer review of the NMFS science in compliance with the predetermined Terms of

Reference (TORs) of the peer review. Three CIE reviewers served on a five-person Panel to evaluate the Collaborative Optical–Acoustic Survey Technique (COAST), developed by SWFSC's Fisheries Resources Division (FRD) for estimating the distributions and abundances of rockfishes in the Southern California Bight (SCB). The Statement of Work (SoW) described in Appendix I was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by the CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest and the report is to be formatted with content requirements as specified in the SoW.

Each CIE reviewer is contracted to deliver an independent peer-review report to be approved by the CIE Steering Committee. This report is independent of the Panel report.

Specific tasks of the CIE Reviewers are:

1) Prepare for the panel review by reading the background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate in the panel review meeting in La Jolla, California during the dates specified in the schedule of milestones and deliverables herein.
3) Conduct an independent peer review in accordance with the ToRs.
4) Submit, no later than 3 March 2012, an independent peer review.

1.1 Goals and Objectives:

The 2012 COAST methodology review meeting provided an opportunity for the Panel members to obtain a comprehensive overview and understanding of the SWFSC acoustic and optical program and associated research. The FRD technical team is to be commended for the level of effort they put into the research, implementation of the COAST program, and overview material provided for the Panel Review. The general goals and objectives of this review were:

1. Ensure that research surveys, data collection, data analyses and other scientific techniques in support of CPS and groundfish stock assessments are the best available scientific information and facilitate the use of information by the Council.
2. Provide recommendations regarding whether, and if so, how a particular methodology can be applied in future stock assessments.
3. Meet the MSRA and other legal requirements.
4. Follow a detailed calendar and fulfill explicit responsibilities for all participants to produce required outcomes and reports.

5. Provide an independent external review of survey and analytical methods used to develop data to inform CPS and groundfish stock assessments.
6. Increase understanding and acceptance of CPS and groundfish research methodologies and review by all members of the Council family.
7. Identify research needed to improve assessments, reviews, surveys, analyses, and fishery management in the future.

It is important to note that the following report to the CIE reflects my independent opinions and views on the issues and questions identified in the terms of reference, statement of work, and the above goals and objectives. The report is, however, generally consistent with the recommendations and conclusions of the other panel members and CIE reviewers. Overall, there was general consensus among the panel members with no identifiable areas of disagreement.

2.0 REVIEW ACTIVITIES

The CIE reviewers essentially served two roles on the Panel Review of SWFSC COAST Rockfish Survey Review. First, to participate as a full panel member in the review of the practices and procedures involved in the COAST approach, and second to provide an independent review of the methodology and process. It was the original intent of this reviewer to provide a copy of the Panel's summary and recommendations in an appendix of this report. Unfortunately, the final Review Panel was not available at the time this report was submitted. Regardless, there was general agreement among the panel members on all aspects of the review. Note that the terms of reference of the panel differ slightly from those for the CIE reviewers. The Review Panel TOR's are described in a document entitled "Terms of Reference for the methodology review process for groundfish and coastal pelagic species" which included the Panel's goals and objectives, general responsibilities, and a template for the review panel report. In addition, the panel was provided with an e-mail dated October 27, 2011 from Steve Ralston identifying a few issues for consideration by the Panel.

The review process began with the SWFSC technical team leader, Dr. Dave Demer, making available the background material necessary to undertake the review. This included primary publications, survey reports, and an overview of the methods and conclusions regarding the COAST methodology. In addition, several papers in press and not included in the original package were supplied to the panel during the meeting to provide further details of survey methods and analytical procedures. All papers/documents necessary to conduct the review were provided to the reviewers well in advance of the meeting (two weeks of the review meeting via e-mail) allowing the panel members plenty of time to review prior to the site visit.

The Review Panel convened at the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC) Torrey Pines Court Laboratory, La Jolla, CA, from 15-17 February 2012 to conduct an independent review of the COAST method. The panel consisted of 5 members: a chair, Martin Dorn, Scientific and Statistical Committee (SSC), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center; André Punt, SSC, University of Washington; and 3 Center for Independent Experts (CIE), Luiz Melo, Gary Melvin, Stéphane Gauthier. The COAST technical team consisted of Kyle Byers, Randy Cutter, David Demer (Team Leader), Kevin Stierhoff, and Juan Zwolinski, all from the NMFS Southwest Fisheries Science Center. Remote participants from the SWFSC Santa Cruz Laboratory included: EJ Dick, John Field, NWFS, Mary Yoklavich, and Alec MacCall. A detailed list of all attendees is included at the end of this report in Appendix 4.

In general, the Panel review adhered to the agenda provided to members prior to the meeting. However, some flexibility was permitted by the Chair when the discussion led into an area to be discussed later, which was helpful to address the issue on-hand. Each CIE Reviewer participated in the discussion and review of the specific topics identified in the agenda and made a significant contribution to the Panel's draft summary report. The review Chair will collate the draft text and complete the Panel report. The review can be divided into four broad topics; the overview, optical surveys, acoustic-trawl surveys, and acoustic-optical surveys, each which are discussed below.

2.1 Overview:

The review panel meeting began with Dr. Martin Dorn opening the meeting. Dr. Francisco Werner, Director of the SWFSC, welcomed all participants and provided some background to the COAST project. This was followed by a technical team overview presentation of rockfish biology, habitat, and behavior, as well as the current sampling, assessment, and management to put the project into context. The take home message from the overview was the complexity of the task, given that 56 species of rockfish are known to occur in the Southern California Bight (SCB). In essence, rockfish species can be aggregating or solitary, diurnal or nocturnal, and occur in the pelagic, benthopelagic, or benthic habitat. This diverse group of fishes makes it difficult to design and conduct a quantitative survey using any of the standard survey approaches. For the purpose of this review, the panel focused the evaluation on those species known to occur in the SCB, but recognized that rockfish occur elsewhere along the Pacific coast; and that the methods employed in the SCB may be appropriate for other areas as well.

A major challenge to the COAST program was partitioning the species into those that were/could be observed acoustically, those that might be observed acoustically, and those that would never be observed acoustically. The initial

division was based on the known biology and behavior of the species. Nocturnal species were also excluded as most acoustic surveys were conducted during the daylight hours. A major amount of the acoustic survey effort was devoted to documenting the occurrence and distribution, both vertical and horizontal, of rockfish on the survey banks. It is believed that many species of rockfish do not venture very far off bottom. However, the panel was provided with a brief summary of the acoustic tagging program that clearly illustrated that some species of rockfish migrate daily up to 50m off the seafloor making them accessible to the acoustic surveying. This topic will be addressed again later in the report.

The survey area and the design for the acoustic and optical surveys are based on a number of factors. In the southern California Bight there is a long tradition of rockfish marine sportfishing by Commercial Passenger Fishing Vessels (CPFV). Through collaboration with this group the COAST technical teams was able to identify the distribution of rockfish on banks in the SCB to focus their research/survey activities. Each Bank or location was post stratified into 4 stratum; shallow, deep (>150m), high density rockfish, and low density rockfish (acoustic estimates) based on previous surveys. Effort for the optical surveys was allocated primarily in the high density areas of a bank. Overall 21 of the 44 surveyed sites have been analyzed. The 43 Fathom Bank closed area has been the focus of repeat surveys since the first COAST survey in 2003.

2.2 Optical Surveys:

A presentation was made by Kevin Stierhoff on the optical survey program. This general overview provided an excellent summary of the optical surveys, the equipment currently used and proposed for the future, as well as the general methodologies employed. Details such as the lighting, platform orientation, speed, distance off bottom, and visual range provided an introduction to most aspects of the survey. Operationally, there were a number of questions on how the surveys were conducted and the visual range of the camera. Observations/counts were conducted primary in the near bottom zone (<3m) where most of the rockfish were observed to concentrate: however, occasionally the camera's pitch was adjusted to look up changing the field of view and the range of the observations. Information on the amount of time spent in each orientation was requested, and received, by the Panel to explore observational bias related to the vertical distribution of rockfish biomass. Selection of optical transects was based on the stratification of 2 covariates; depth (shallow and deep) and recently in acoustic rockfish density (high and low). Deployments were assigned to sample the strata, although the number of transects for any given survey at any given site/location rarely covered all 4 strata. In some cases data from past surveys appears to have been pooled or substituted to provide an estimate of species proportions for the feature or location. A major point of discussion was the representativeness of proportions of rockfish species observed in the optical survey and the acoustic survey. The panel was presented

with evidence from a single echogram that rockfish in the water column compress vertically in the presence of a submerged survey platform (ROV, AUV, submarine) making them visible to the optical survey. It is assumed that they occur in the optical survey in the same proportions as they occur in the water column. No information was presented on the possible horizontal reaction to a survey vehicle. The optical survey observations were not used directly for quantitative biomass of individual species of rockfish and raw counts of each species were used to estimate species proportions for input to the coast method. Several groups of unidentified fishes were established for apportioning the acoustic backscatter.

Length measurements of individual rockfish species are necessary to compute target strength and subsequently apportion the acoustic backscatter with a weighting function. Rockfish total lengths (cm) were measured during the optical survey and grouped into 4 broad sizes, <10, 10–25, 25–60, and >60cm, with parallel lasers. The number of length samples was small, with no information for some species. Given the small number of length measurements a Gaussian distribution was fitted to the length measurements for the individual species. For some species literature data on the minimum and maximum length, fitted to a normal distribution, were used to estimate fish size. This may not be the best approach to describe the distributions. More length information is required for all species. This will hopefully be corrected when a stereo camera system is deployed in the future.

2.3 Acoustic-Trawl Surveys:

Extensive acoustic surveys have been conducted on banks throughout the SCB under the COAST program. The technical team is to be commended for its effort, creativity, and analysis in the conducting of these surveys. Many of the surveys and specific research activities have led to scientific advancements and novel approaches to address acoustic issues. The intensity of acoustic coverage has provided the team with sufficient data to explore COAST related problems. The surveys followed traditional acoustic survey design with parallel lines, in this case closely spaced, to cover a predefined area. However, in the COAST surveys the sampling unit at the bank level was a 50 m segment of the cruise track, including the between line data, not just the usual transect.

Detailed information was provided on the approach used to acoustically define the seabed based on the S_v data from the 4 frequencies and the interferometric phase samples. This technique developed by the COAST team resulted in high-resolution 3D imaging of the seabed and estimates of within beam bottom slope, hardness, and roughness upon which the seabed was classified into potential rockfish habitat was based. Another important factor in estimating the backscatter for subsequent biomass estimation is the extent of the acoustic dead zone which, depending on the bottom slope, can range from a few tens of cm to multiple meters. Research conducted during the COAST developed a method to

estimate the acoustic dead zone for each ping, thereby providing a mechanism to evaluate what might be missed or hidden acoustically and to filter bottoms where the dead zone was large, on a ping-by-ping basis. Currently samples with a dead zone of >3 meters are excluded from the analysis and no adjustment is made for fish in the dead zone.

Multi-frequency acoustic data were also used to pre-filter the backscatter and resampled masked frequency response/differences used to associate the S_v with rockfish. Some thresholding was also employed to further isolate the backscatter attributed to rockfish. Once identified only the 38 kHz data were integrated for biomass estimates. Target strength estimates for all rockfish are based on a single model (Kang and Hwang) but adjusted for species size and weight. Data presented to the panel suggested that the model may not be far off given *in situ* measurements during COAST surveys and additional modeling. The technical group will continue to use the single model for the analysis for the near future.

2.4 Acoustic-optical surveys:

Both the acoustic and the optical surveys generally utilized standard survey approaches to collect data over a predefined area, albeit several innovations have evolved from the COAST program. The challenge comes when the data are brought together to apportion the acoustic backscatter into rockfish species, and the technical group acknowledge the complexities and uncertainties associated with their approach in the documents provided to the review. Acoustic technology will document targets through the water column, but there is an acoustic dead zone near the bottom where fish cannot be detected. On the other hand, optical surveys have limited visibility range and usually collect information very near bottom. Both surveys only overlap in coverage slightly and the apportioning of the acoustic data into species is based on a number of assumptions which affect uncertainty and bias. The technical team has assumed that when the rockfish are compressed vertically in the presence of an underwater platform, the reaction is non-species specific and the optical observations are proportional to their natural day time state; thus an unbiased representative sample of the fish present in the acoustic observations can be obtained from the optical survey. Furthermore, after reviewing the literature they propose that approximately 10 of the 47 species identified (Table 4, Coast overview document), known to live hard on bottom or are nocturnal, would never be detected acoustically. Unidentified fish are classified into broad categories of similar like rockfish.

The methodology used to apportion the acoustic backscatter is accepted practice, however the assumptions made about species composition and fish distribution can have serious implications in the interpretation of the COAST methods and the rockfish assessments. Several aspects of the approach were investigated by the Panel and will be discussed in the CIE Summary of Findings and the Panel's report (not yet available). The following summarizes the Review

Panels requests for additional information and is a direct excerpt from the draft report completed at the meeting.

2.5 Requests made to the Technical Team.

A. Provide the algorithm used to allocate raw data on optical observations to estimate species proportions (including how account is taken of unidentified species, observations at different pitch angles, etc.)

Rationale: The documentation provided to the Panel did not include this information.
Response: The equation to apportion the s_A of all rockfishes to the s_A by species is given in Equation 2 under the section Target strength estimation. The weighting factor w_i represents the summed species biomass within the part of the Remotely Operated Vehicle (ROV) track that spans the respective depth stratum and TS_i is the average target strength for the i^{th} species. Fish counted as unidentified were assigned to one of five categories (Sebastomus, Sebastes, Complex 1, Complex 2 and Complex 3; Table 1). Fish not assigned to the Sebastomus complex were attributed to the nearest species along the ROV track that was a member of their complex. The counts of unidentified species were partitioned proportionally to all the fish on the track when both the previous and the following species counts along the ROV track did not match any of the potential species. Fish counted as Sebastomus were apportioned proportionally to the counts of the species assigned to the category.

B. Estimate the biomass in the deadzone for an example bank under the assumption that the density just above the deadzone matches that in the deadzone.

Rationale: The density in the deadzone is currently assumed to zero, and the Panel wished to obtain an impression of the likely size of the negative bias associated with this assumption.
Response: For Cherry Bank, distributions of s_A were presented by three classes of deadzone height (Fig. 1). The net consequence of correcting for the deadzone by extrapolating the s_A in the 1m bin above the deadzone to the deadzone was an increase to the nominal biomass of rockfish of approximately 15%.

C. Construct a table of the frequency of the use of the four methods for assigning species proportions to sites (same site and survey, same site different survey, different site same survey, different site and survey).

Rationale: Ideally, the species proportions for each site and survey should be based on optical transects during that survey at that site. However, this does not always occur. The Panel wished to understand the extent to which extrapolation of species proportions is occurring.
Response: Targeting shallow strata but with limited ROV time no time for deep stratum ROV transects. Table provided.

D. Provide a histogram of the deadzone height (50cm bins above the bottom) by stratum (high vs low density; deeper or shallower than 150m).

Rationale: The Panel wished to understand the potential amount of deadzone. The algorithm used to analyse the data excludes samples with deadzone height > 3m.
Response: Figure 2 shows the distribution of deadzone heights for Cherry Bank (integrated over strata) while Figure 3 shows the distributions of deadzone heights for 43 Fathom Bank. More than 90% of the samples for 43 Fathom Bank had a deadzone height < 3m. The only stratum in Figure 3 with appreciable amounts of deadzone > 5m was the high density deep stratum (~55% of samples), but there was little biomass in this stratum. For the remaining strata, the bulk of the deadzone heights was < 1m.

E. Provide the estimates of biomass by deep and shallow strata and site categorized by the four methods for assigning species proportions to sites.

Rationale: The Panel wished to further understand the implications of having to use data from different surveys or sites to apportion total biomass to species.
Response: Information provided in new slide presentation

3.0 Summary of Findings:

The following provides a summary of findings based on the terms of reference specific to the CIE reviewers. Each TOR will be addressed and discussed to meet contract requirements, however, most of what is reported below is redundant and in general agreement with the Panel Report that was only available in draft form at the time this report was prepared.

1 Review documents detailing COAST survey and data analysis methods and results according to the PFMC's ToR for Stock Assessment Methods Reviews. Document the meeting discussions.

The review activities presented above describe the information made available to the Review Panel. The SWFSC technical team provided an excellent summary of the technologies used, survey design, analytical methods, and results during the 3 day meeting. This information greatly assisted the Review Panel in their review of COAST approach. In addition to the original documents provided before the meeting, several new or incomplete reports were made available during the meeting when they were deemed to provide supplementary information to the ongoing discussion. When the Panel requested more detailed explanation or additional analysis, the team generally provided the information the next day. The Panel and the CIE reviewers appreciated their efforts and acknowledge the extensive research undertaken to evaluate factors that may affect or bias the COAST output. The documented and presented information was sufficient to conduct the Methodology Panel Review and generally represents the best scientific information available at the moment. However, from the presentations it was obvious that a significant portion of research is still ongoing, data analyses in progress, and survey results to be completed, that could further assist the decision making process regarding COAST. It is **recommended** that this information be completed as soon as possible and assimilated in the context of recommendations from the Review Panel.

2 Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of bocaccio, cowcod, vermillion/sunset, bank and other rockfishes in the SCB, and associated sources of uncertainty.

The Review Panel focused its review on survey methodology of the acoustic surveys, the optical surveys, and combining the two through the COAST approach rather than address the issues specific to an individual rockfish species. Species specific concerns were addressed under the general issue of representative samples and species composition. The survey site selection and effort in SCB was based on historical landings and records of the CPFV captains. While this information is extremely valuable and the collaboration encouraged, there may be some bias associated with the approach. Typically, the sportsfishing industry will focus its efforts on desired, large, and/or favorite species, concentrating their effort at locations of good fishing, which could subsequently lead to a bias toward locations where desired specific species or aggregations of species occur. Several rockfish species may be common in the SCB but not actually observed in the sports fishery. More information on the distribution and habitat of the specific rockfish species needs to be obtained.

Intensive acoustic surveys were undertaken in collaboration with the California sportsfishing industry utilizing the RV “David Starr Jordan” and CPFV “Outer Limits” using hull mounted multi-frequency scientific echo-sounders on rockfish habitat (banks) identified from the historical recreational catches. Each survey location was stratified into deep or shallow (<150m) and post stratified in high or low rockfish density from the acoustic data. While the depth strata are fixed, the

diversity strata spatial coverage may vary from year to year based on acoustic observations. This stratification approach was deemed acceptable by the Panel, but some concern was expressed about the inter-year/survey variability of the stratum.

In essence the COAST acoustic surveys followed standard acoustic survey protocols, except the intensity of transects was much greater than typically utilized. Overall, the current site stratification approach will reduce bias and the intensity of transects will reduce the variance at a specific location. Unlike most coastal pelagic species (CPS) which generally have to deal with only a few species (<5), the COAST surveys have to contend with estimating biomass for 19 or more species in any given year. A standard approach was used to apportion the backscatter based on a weighting ratio from the optical observations and the TS/weight ratio; however, the apportioning of backscatter to a specific species is contingent upon the optical observations providing a representative sample of the species detected in the acoustic beam. The species complexity and variable distribution will be addressed further in the section on representative samples from the optical survey.

As with all acoustic surveys another challenge lies in dealing with the variable, seabed slope dependent, boundary layer between acoustically visible and the acoustic dead zone. The technical team has exerted a large amount of effort in estimating the ADZ and has utilized several novel approaches in slope determination and seabed classification that have been published or are in the process of being published. Currently, no samples with an ADZ greater than 3m are included in the analysis and no correction in made for biomass in the ADZ. The Panel requested, and was provided with, information on the distribution of dead zone depths and an estimate of biomass in the ADZ to evaluate the extent. The majority (>90%) of samples from 43 Fathom Bank had an ADZ of <3m. Based on S_A observations 1m above the ADZ being extrapolated into the ADZ approximately 15% of the nominal biomass went undetected. It is **recommended** that further analysis of ADZ be undertaken and that alternative approaches to estimating biomass in the ADZ be investigated.

Acoustic visibility of the various species was another topic the Panel discussed in some detail. Given the large number of species potentially available, their different habitats, and behaviour the question was raised as to what species were available for acoustic detection. The overview report provided prior to the meeting summarized rockfish social behaviour, seabed habitat and seabed proximity used to exclude certain species from the acoustic analysis based on the likelihood on them being observed above the acoustic dead zone. This is a key point in the estimation of biomass expanded over such a broad area as the proportions will exemplify any error and the assigning of backscatter to a species that is not acoustically visible will not only diminish the estimate of the other species, it could create an artificial impression of stock status. At the meeting, it was apparent that far more information was available to address the issue of

vertical distribution of individual rockfish species was available. It is **recommended** that a group of rockfish experts meet and their collective wisdom be utilized to describe the habitat and behaviour of the many species that occur in the SCB.

Target strength of an individual rockfish species is critical to the apportioning of backscatter and the subsequent biomass estimates from the acoustic backscatter. Target strength is a function of many factors including species, size, and frequency. The Panel was presented an overview of several analyses used to indicate that the current single TS model (Kang and Hwang) for all rockfish species was within acceptable limits, although it is known to vary between species. At present only the 38 kHz data are used to estimate biomass from species specific length weight relationships primarily from Love *et al.* to convert. Fish length is determined from the optical observations. The Panel **recommends** that further research be conducted into the effects of a single TS model on biomass estimates and the possibility of developing a species specific TS model for some of the more common species be explored.

The COAST approach uses a different definition of sampling unit than traditional acoustic surveys. For each location or bank, the vessel track (transect) is divided into 50m segments and an estimate of mean s_A made for each of the stratum, but no estimate of site specific variance is made. The mean values for each bank and stratum are then used to estimate the mean and variance for the SCB. In essence for biomass calculations the sample unit was a bank and error estimates represent inter-bank variability, not intra-bank. While the panel found this method acceptable it noted that it was possible to estimate a mean and a variance for each bank, thus allowing the comparison of inter-annual variation of a bank or group of banks.

The primary objective of the **Optical Surveys** was to estimate the contribution (proportion) of each rockfish species to the overall acoustic backscatter. The observed proportions were then used to apportion the backscatter into individual species or assemblages of species. The technical team presented a significant amount of background information on the optical surveys, the equipment currently used and proposed for the future, as well as the general methodologies employed. Details such as the lighting, platform orientation, speed, distance off bottom, and visual range provided an introduction to the operational aspect of the survey. Unfortunately, insufficient data were originally provided on how the proportions were actually estimated from the raw optical observations. This information was requested and provided to the Panel.

Deployment of the optical system was limited and the spatial coverage sparse relative to acoustic surveys. Although attempts are now made to undertake an optical survey of every bank acoustically surveyed with a focus on the dense strata, it is not always possible to complete the optical surveying due to time allocations, weather, and operational logistics. At several sites and in the low

density stratum there are no optical surveys. Optical survey data from another survey year at the same location or another bank are to be substituted to estimated species proportions. Even for repetitive sampling over several months the data from a single optical survey may be used to estimate the species contribution. On 43 Fathom Bank the same optical data were used to estimate the proportional contribution of rockfish for four acoustic surveys conducted between August and November. Optical surveys for all acoustic surveys should be encouraged. The temporal and spatial substitution could introduce a bias due to inter-bank differences in species composition, migrations, density dependent factors, and general behavior. It is **recommended** that the temporal and spatial variability of species composition be investigated further. The technical team has suggested that acoustic effort could be reduced and more optical transects be undertaken to obtain additional data.

A key component in the estimation of target strength, fish weight, apportioning of acoustic and the species specific biomass is fish length. The current approach uses parallel lasers to estimate the length of fish observed by species. Unfortunately, this method proved to be limiting in both the number of samples for each species and the accuracy of the measurement. Broad size categories were established in some cases and species specific weight length relationships were extracted from the literature. Efforts were made to adjust the measurements by fitting the species specific data to a Gaussian distribution. This may not be the best approach given the observed fish length distributions. Overall, few length distribution measurements were available for most species. This has been recognized by the technical team and will be corrected in the future by using a stereo camera that will allow measurement of individual fish over a broad range of orientations. Methods to get finer scale empirical length data of individual rockfish species should be encouraged.

There are limitations to the visual distance and vertical range of the camera system. Typically the camera is deployed from an underwater platform flown less than 2 m off the seabed tilted down to concentrate on the bottom few meters looking out to about 5 meters. On occasion the camera is tilted up to look at the fish in the water column. Counts of individual species and several species complexes are used to estimate the proportion representation of each rockfish species and assemblages. Visual observations of the water column were not based on the vertical distribution of biomass, concentrated on the lower few meters, and looked up at the discretion of the operator (i.e., at no regular intervals), possibly introducing an observational bias. A request to provide a summary of the vertical distribution of biomass indicated that the majority of biomass was above the general observation of the optical survey. Furthermore, if differences are found in species proportions among ROV tilt angles, the species proportions by tilt angle should be weighed for proportion of time allocated to each tilt angle. The Panel **recommends** distributing the observation effort with the ROV equally across tilt angles, rather than simply looking up “once in a while”.

One of the main concerns of the optical survey is the assumption that the proportional composition of observed species is representative of their distribution in the water column at the time of the acoustic surveys. The panel was presented with evidence from a single echogram that implied rockfish in the water column dive vertically and are compressed very near bottom in the presence of observational platform (ROV, AOV, submarine). Consequently, the observed proportions (species mixture) of fish in the optical survey are consistent with the proportions observed in the water column. No information was reported on whether or not rockfish move horizontally, diagonally, or completely avoid the underwater platform without moving into the optical observation field of the camera. As an example, Public attendees implied that the chillipepper rockfish are common at some sites but are not represented in the optical observations. This suggests they [chillipepper rockfish] may be available to the acoustics but not to the optics.

The panel felt that given the critical nature of representation to combining the acoustic and optical data (i.e., the COAST method) that far more evidence than a single echogram needed to be evaluated. The technical team noted that there was a fair amount of collected information available to address this issue, but it was not presented to the Panel. Further research into this subject needs to be conducted. The assumption of random distribution should be tested by testing for differences in species proportions by ROV tilt angle. The Panel **recommends** that experiments with drop or still cameras would provide useful information on the distribution of each species across the camera field of view. Another possible method to investigate fish behaviour in the presence of an underwater platform would be to use multi-beam sonar to monitor the reaction or behavior of fish. The Panel also **recommends** testing whether the species proportions differ between high and low density habitats as defined by acoustics observations. The current analytical approach assumes that species proportions are the same in all strata. While such tests may have low power because of low sample size, they should be conducted and the optical data stratified between high and low density strata if significant differences are found.

Initial screening or exclusion of rockfish species from the analysis was based on whether or not the species would be detectable acoustically. Species identified from a literature review as benthic and/or solitary were not considered to be available to the acoustic technology as they would likely permanently inhabit the acoustic dead zone. While the current approach is objective and repeatable, the Panel noted that it is not necessarily easily justified given the inconsistencies among rockfish experts on the behaviour of individual species. It is **recommended** that sensitivity tests be conducted for excluding species and that a group of rockfish experts convene to establish the depth distribution and responsive behaviour of the rockfish species encountered during COAST surveys.

The basic assumption that the optical survey observed species proportions were a good proxy for the water column composition and that they provided an unbiased representation of the vertical distribution are critical to the COAST approach. This assumption and the implicit random vertical distribution of rockfish is likely the most contentious issue in merging the two survey approaches under the COAST program.

Integrating the two sampling methods under COAST raised a number of issues related to survey design, abundance estimation and quantification of uncertainty. For several sites optical data are not available in the year of the acoustic survey and species composition from another site or survey are substituted for biomass estimates of multiple rockfish species. Site fidelity would imply that species composition should not change. Which type of substitution is most appropriate is uncertain, but the practice would lead to among year-correlations in biomass estimates. Sensitivity tests which explore the implications of the two approaches should be conducted to evaluate the likely magnitude of the choice among these options. COAST uses TS estimates based on fish length as part of the weighting function to apportion the acoustic backscatter. Unfortunately, the lengths are based on a few broad length interval measurements to estimate species specific TS. A more accurate estimate of the observed species length frequencies may be required for stock assessment purposes. However, the largest source of uncertainty with the COAST approach is the assumption that the species proportions estimated from the ROV transects are representative of the fish acoustically surveyed. It is also greatest potential source of bias.

3 Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for multiple rockfish species.

The utilization of the COAST method to monitor trends in abundance at the population level will depend upon the resolution of a number of issues identified above. The technical team has made great progress toward the utilization of COAST in the stock assessment but they are not quite there. Several factors need to be considered further and some of the uncertainty must be addressed. First, a major issue and likely the greatest source of potential bias is the ROV species composition being representative of the species proportions measured in the acoustic survey. Second, the estimate of TS is based on only a few broad length intervals for a few species. More length frequency measurements are required for assessment purposes and a more accurate TS estimate. Third, incomplete optical sampling at all sites for the survey year could lead to inter-site or inter year correlations. Improved optical sampling is required. Forth, species specific differences in catchability (q) or discrepancies in rockfish species detection by ROV surveys has the potential to be a serious methodology issue for COAST, especially when the species constitutes a large proportion of the overall biomass. There also appears to be some inconsistencies between the

preliminary COAST biomass estimates and other assessment biomass for some species. The Panel was informed that the biomass estimate for shortbelly appeared to be much lower than expected given the results of stock assessments.

Characteristically for an index of biomass, either absolute or relative, there needs to be an estimate of biomass with measures of precision for a known component of the population. The index does not have to cover the entire population distribution, but it must represent a relatively constant proportion of the population biomass. In addition, if trends are to be monitored, a time series with standardized protocols and analytical procedures are required if trends in biomass are to be monitored and not the inter-annual variability. In the COAST program coverage is limited to the areas identified from historical sportsfishing catches, but rockfish species are known to occur in other areas in SCB and further north. Coverage could be extended north where the species composition is not so diverse. No biomass estimate was provided for the entire SCB at the meeting. Instead information on about 50 percent (21 of 44) of the surveyed locations was used to illustrate the process; the remaining sites are still to be analyzed.

The COAST approach has the potential to be utilized as a standalone method for quantifying rockfish biomass in the SCB and as an index of abundance for stock assessment models for a broader scale distribution assuming the issues identified above can be addressed. In addition the method could be used to monitor the status of specific banks of interest to evaluate the effects of management actions over time. There are a number of unresolved problems and major uncertainties outstanding and include: (i) complications associated with species diversity and the subsequent estimation of species proportions; (ii) equal detectability of species in the area acoustically detectable; (iii) equally distributed in the view of the ROV; and (iv) avoidance behavior is equal for all species. Ultimately, it is likely that the COAST approach will be found to be appropriate for the assessment of some rockfish species, questionable for some species, and inappropriate for other species – which species fall into each of these categories has yet to be defined.

There is also the possibility that the optical surveys could be used as an independent estimate of species specific biomass. The Panel discussed this option and suggests that it be explored to compare with other biomass estimates. Using the optical survey alone would eliminate the apportioning required to merge two independent sampling methods. Direct counts of number could be used to estimate fish densities for specific seabed types.

4 Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

Assuming the major sources of uncertainty can be overcome, the COAST approach could become an effective for detecting change over a variety of spatial scales. Currently, the survey is designed to be comprehensive for rockfish species throughout the entire SCB, although there are some notable omissions in habitat coverage such as the near shore areas and numerous other banks. At present the rockfish populations in these uncovered/unsurveyed areas may be at very low level, or include high densities of undesirable species; however, it is hoped that at some point there will be a recovery. If the COAST approach is to be used as an absolute index of abundance then these areas need to be considered. Comparison of COAST results with other assessment surveys in the SCB would help to identify rockfish not covered by the COAST sites.

Currently, the COAST approach is proposed to provide a biomass estimate for a broad range of rockfish in the SCB. Estimates of biomass are based on a mean and variance using each survey site as a sampling unit to obtain a biomass estimate for the entire Bight. However, this does not prohibit the use of the results from a single or a group of banks being used to monitor biomass trends in areas of interest or to evaluate the effect of specific management initiatives. For example, the Cowcod closure has been in place for a number of years. Stratifying the data into "within" and "outside" the closure would allow the investigation of questions such as has there be an increase in rockfish biomass since the closure (or in recent years) or is there a difference in observed fish densities inside and outside the closed area. Individual banks of special concern or interest could also be monitored using the COAST approach.

The intense survey coverage of 43 Fathom Bank over the past 3 survey years provides an excellent opportunity to investigate a number of issues related to using the COAST approach in fish stock assessment. Continued monitoring of this bank will allow researchers to investigate inter and intra survey variability in species distribution, composition, and biomass of many of the species found throughout the SCB. Some consideration might also be given a night acoustic and optical survey to determine diel distribution, species contribution, and abundance of fish.

5 Decide through Panel discussions if the ToRs and goals of the peer review have been achieved.

Upon completion of the review meeting on Friday (February 18) the Panel went through each of the terms of reference to ensure the Panel Chair was satisfied that we had addressed all of the terms of reference. It was agreed by the members that we had met all the TOR's and addressed the major issues defined prior to the review meeting. There were also no areas of disagreement among the panel members. In addition, we completed a rough draft of the Panel report with contributions from all panel members. The Panel Chair will edit the draft and will submit the final version of the report within a few weeks. Overall, there was general agreement on all issues and recommendation resulting from the review.

The review process provided an opportunity for an open scientific discussion on all aspects of the COAST approach. Material necessary to undertake the review was provided on time and additional information when requested to address specific issues as they arose. A competent and professional technical team was made available to the review panel to provide an overview of the project and to answer the Panels questions. Panel members also encompassed a broad spectrum of experience in stock assessment, acoustic surveying and technology, and optical surveying. These can only be described as strengths of the overall process and are a reflection of the organizers. If I had to identify a weakness in the process it would be that there appeared to a significant amount of ongoing research and data analysis to be completed that could have contributed to at least some of the issues raised at the review. Perhaps the review meeting should have been delayed by 6 months to allow some of the research to be completed. However, one of the objectives of the review was to provide guidance on how to proceed.

4.0 Recommendation and Conclusions

The Panel concluded that data from COAST program could be used in rockfish stock assessments as measures of absolute abundance, if there is no substantial bias due to inadequate spatial coverage, species proportion estimates, and catchability, or if a prior distribution for the average level of bias can be developed, or as a relative index of abundance for input to assessment models. However, there are a number of outstanding issues that must be addressed before the method can be utilized to monitor stock status and to inform management in the decision making process. The following draft recommendations are those agreed to by the Panel prior to the closing of the meeting. Slight modifications to the recommendations may occur in the final Panel Report when released, but not the content. All recommendations are consistent with those of the CIE reviewer.

1. The estimates presented to the Panel did not include a deadzone correction whereas the species proportions from the optical transects represent animals that would have been in the acoustic deadzone. The proportion of the biomass in the deadzone is likely to be sufficiently large that application of a deadzone correction is justified. Consider additional approaches for calculating the deadzone correction and evaluate the sensitivity of results to different approaches (including no deadzone correction).
2. Conduct an analysis of whether the species proportions inferred from the optical transects differs among sites within a survey year, among years for a given site, and among the strata used within a site (deep vs. shallow and high vs. low density). Evaluate the power to detect differences.

3. Evaluate, based on the preliminary results, the power to detect changes in the abundance of species of particular concern to the Council (e.g. cowcod, and boccacio).
4. Explore methods to estimate the depth distribution of each rockfish species using techniques which should be less "invasive" than ROV and submersibles (such as drop camera and hook-and-line surveys). Taking due account of the likely impact of these techniques on the behaviour of the surveyed species, evaluate the depth distribution of the surveyed species and hence which are likely to be adequately surveyed by acoustics.
5. Continue work to estimate species-specific target strength and employ species-specific estimates if this is supported by the results of analyses.
6. The extent to which rockfish react to the ROV will differ among species. The estimates of species proportions (and hence abundance) will be biased if some species are less likely to be detected optically than others. Explore methods to estimate how the probability of detection (horizontal avoidance) differs among species and correct the species proportions if needed.
7. Test whether the species proportions differ as a function of the height off the bottom. If so, compute species proportions for each transect weighting the species proportions by depth class by the proportion of effort by depth class. Optical survey efforts should be more equally distributed across tilt angles in future surveys
8. Conduct an analysis to identify the optimal allocation of acoustic and optical transects to strata and the relative effort by these two methods given a fixed total cost. Account in this analysis for the correlation in density estimates among acoustic transects.
9. Evaluate the extent of among-observer differences in species identification.
10. Convene a group of rockfish experts to develop a consensus view on the depth distribution and responsive behaviour of the rockfish species encountered during COAST surveys. Use this information to develop criteria to select which species to exclude when estimating species proportions from the optical data.
11. Conduct a direct comparison between the ROV estimates of abundance on those using COAST methods through an intensive survey of a small number of sites. Stratify the comparison by deadzone height.
12. Estimate species composition by 50cm bins above the bottom by stratum and whether the location is estimated to be in the deadzone using the GAM model of the habitat.
13. Better detail on length composition is needed. Use more accurate methods (e.g. stereographic camera system) to get sufficient length samples for each species in the survey.
14. Consider alternative variance estimation methods, including methods based on among-survey variation in density within sites. Ideally, an

attempt should be made to estimate a functional form relating the coefficient of variation of density to site area, effort, etc.

DISCLAIMER

The information in this report has been provided for review purposes only. The author makes no representation, express or implied, as to the accuracy of the information and accepts no liability whatsoever for either its use or any reliance placed on it.

Appendix I:

Statement of Work for Dr. Gary Melvin

External Independent Peer Review by the Center for Independent Experts

Panel Review of the
Collaborative Optical–Acoustic Survey Technique (COAST)
for Surveying Rockfishes

15-17 February 2012

Scope of Work and CIE Process: The National Marine Fisheries Service (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer-reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by the CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. The CIE reviewers are selected by the CIE Steering Committee and the CIE Coordination Team to conduct the independent peer review of the NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer-review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: Three CIE reviewers will serve on a five-person Panel to evaluate the Collaborative Optical–Acoustic Survey Technique (COAST), developed by SWFSC's Fisheries Resources Division (FRD) for estimating the distributions and abundances of rockfishes in the Southern California Bight (SCB). However, the method could be used to survey other demersal fishes in other areas. The COAST uses historical fishing maps or other habitat information to initially define survey areas; data from ship-based multi-frequency echosounders to map the acoustic backscatter from rockfishes in these areas; and video and still images from cameras deployed on a remotely operated vehicle (ROV) to quantify the proportions of species, and their size-distribution, in acoustically-detected mixed assemblages. The optical information is used to apportion the rockfish backscatter to species, calculate their length-dependent target strengths, and estimate and map their biomasses. The optical information could be obtained using other camera platforms, e.g., submarines or autonomous underwater vehicles.

In 2003, 2004/5, and 2007/8, the FRD conducted COAST surveys, in collaboration with the Sportfishing Association of California (SAC), to estimate the distributions and abundances of rockfishes, by species, throughout the SCB. The information from these and future surveys may be used to: improve assessments of multiple rockfish species; investigate the relationships between rockfishes and environmental factors, e.g., temperature, salinity, oxygen concentration, and depth; and scientifically evaluate the effectiveness of the Cowcod Conservation Area (CCA) and other management strategies. The Panel report will be used to guide improvements to the COAST survey and analysis methods, the resulting time series of estimated rockfish abundances and distributions, and estimates of their uncertainty. The Panel report will be considered by assessment analysts, but Stock Assessment Review (STAR) Panels will review the assessment models.

The Pacific Fisheries Management Council's (PFMC's) ToRs for the Panel review are attached in **Annex 2**. The tentative agenda of the Panel review meeting is attached in **Annex 3**. A Panel Summary Report Template is attached as **Annex 4**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The CIE reviewers shall collectively have the working knowledge and recent experience in the application of fisheries acoustic and optical sampling methods; survey design; and stock assessment. The duties of each CIE reviewer shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location/Date of Peer Review: The CIE reviewers shall participate as independent peer referees during the panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 3333 North Torrey Pines Court, La Jolla, California, 92037-1023, during 15-17 February 2012 in accordance with the agenda (**Annex 3**).

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Following selections of CIE reviewers by the CIE Steering committee, the CIE shall provide the reviewers' information (names, affiliations, and contact details) to the COTR, who will forward this information to the NMFS Project Contact (PC) no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the Reviewers. The NMFS project contact is responsible for providing the Reviewers with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The project contact is also responsible for providing the STAR Panel Chair

(Chair) with a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When a CIE reviewer who is a non-US citizen participates in a meeting at a government facility, the NMFS project contact is responsible for obtaining a Foreign National Security Clearance for that reviewer. For the purpose of their security clearances, the reviewer shall provide requested information (e.g., name, contact information, birth date, passport number, travel dates, and country of origin) to the project contact at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations (available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the review, the NMFS project contact will electronically send to the reviewers, by email or FTP, all necessary background information and reports for the panel review. If the documents must be mailed, the project contact will consult with the CIE on where to send the documents. The reviewers shall read all documents in preparation for the panel review, for example:

- documents on current survey methods, in particular, related to ichthyoplankton and hook-and-line sampling of rockfishes, and landings data;
- documents on SWFSC COAST surveys conducted since 2003;
- documents from past panel reviews of rockfish sampling methods;
- documents from STAR panel reviews of rockfish assessments, and;
- other documents, including the ToR, SoW, agenda, schedule of milestones, deliverables, logistical considerations, and PFMC's ToR for Groundfish Stock Assessment Methods Reviews.

Each CIE reviewer is responsible only for the pre-review documents that are delivered to that reviewer in accordance to the SoW scheduled deadlines specified herein. Any delays in submission of pre-review documents for the CIE review will result in delays with the CIE review process, including a SoW modification to the schedule of milestones and deliverables.

Panel Review Meeting: Each CIE reviewer shall conduct the independent review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the review, and any SoW or ToR modification prior to the review shall be approved by the COTR and CIE Lead Coordinator.** Each reviewer shall actively participate in a professional and respectful manner as a member of the Panel, and their review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the reviewers and Chair are described in **Annex 2** (see p. 6-8). Each reviewer will serve a role that is equivalent to the other panelists,

differing only in the fact that he/she is considered an "external" member (i.e., outside the PFMC's membership and not involved in management or assessment of west coast rockfishes). Each reviewer will serve at the behest of the Chair, adhering to all aspects of the PFMC's ToR as described in **Annex 2**. The Chair is responsible for: 1) developing an agenda; 2) ensuring that panel members (including the reviewers) and FRD follow the ToR; 3) participating in the review of the methods (along with the reviewers); and 4) guiding the Panel (including the reviewers) and FRD to mutually agreeable solutions.

The NMFS project contact is responsible for any facility arrangements (e.g., conference room for panel meetings or teleconference arrangements). The CIE Lead Coordinator can contact the project contact to confirm any meeting facility arrangements.

Contract Deliverables - Independent CIE Peer-Review Reports: Each CIE reviewer shall complete an independent CIE-review report in accordance with the SoW, i.e., in the required format as described in **Annex 4**, and addressing each ToR as described in **Annex 2**.

Other Tasks – Contribution to Summary Report: The reviewers will assist the Chair with contributions to the Summary Report. The CIE reviewers are not required to reach a consensus, and should provide a brief summary of their views on the findings and conclusion reached by the review panel in accordance with the ToRs (**Annex 1**).

Specific Tasks for CIE Reviewer: The following chronological list of tasks shall be completed by the CIE reviewers in a timely manner, as specified in the **Schedule of Milestones and Deliverables**:

1) Prepare for the panel review by reading the background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate in the panel review meeting in La Jolla, California during the dates specified in the schedule of milestones and deliverables herein.
3) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) Submit, no later than 3 March 2012, an independent peer review report addressed to the "Center for Independent Experts," to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE reviewer shall write their report using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: The CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

January 20, 2012	The CIE sends the Reviewer's contact information to the COTR, who forwards it to the NMFS Project Contact.
Feb 1, 2012	The NMFS Project Contact sends the pre-review documents to each reviewer.
Feb 15-17, 2012	Each Reviewer participates in the panel meeting and conducts an independent review.
March 3, 2012	Each CIE reviewer submits their draft report to the CIE Lead Coordinator and CIE Regional Coordinator.
March 17, 2012	Following any necessary revisions and approval by the CIE Steering Committee, the CIE submits the CIE reports to the COTR.
March 24, 2012	The COTR distributes the final reports to the NMFS Project Contact and the regional Center Director.

Modifications to the Statement of Work: Requests to modify this SoW must be made through the COTR who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToR of the SoW as long as the role and ability of each Reviewer to complete the SoW deliverable in accordance with the ToRs and the deliverable schedule is not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, they shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via email the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards. Each CIE report shall: (1) have the format and content in accordance with Annex 1; (2) address each ToR as specified in Annex 2; and (3) be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via email the final CIE reports in pdf

format to the COTR. The COTR will distribute the approved CIE reports to the PC, and the regional Center Director.

Support Personnel:

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Annex 4: Panel Summary Report (Template)

- Names and affiliations of panel members

- List of analyses requested by the panel, the rationale for each request, and a brief summary of the proponent's responses to each request.

- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies.

- Explanation of areas of disagreement regarding panel recommendations:
  - among panel members; and
  - between the panel and the proponents

- Unresolved problems and major uncertainties, e.g., any special issues that complicate survey estimates, estimates of their uncertainty, and their use in stock assessment models.

- Management, data, or fishery issues raised by the public (i.e., non-panel and proponent participants) at the panel meetings.

- Prioritized recommendations for future research, and data collections and analyses.

Appendix II:

Terms of Reference for the Peer Review of the COAST for surveying Rockfishes

The reviewers will participate in the Panel-review meeting to conduct independent peer reviews of the COAST as it pertains to surveys of rockfishes off the west coast of the United States of America (US), principally bocaccio, cowcod, vermillion/sunset, and bank rockfishes in the SCB. The principal survey area is between the Mexico-US border and Point Conception. Survey estimates are to include absolute biomasses, and their total random sampling errors, and spatial distributions. The review solely concerns technical aspects of the survey design, method, analysis, and results, and addresses the following ToR:

ToR 1 – Review documents detailing COAST survey and data analysis methods and results according to the PFMC's ToR for Stock Assessment Methods Reviews. Document the meeting discussions. Evaluate if the documented and presented information is sufficiently complete and represents the best scientific information available.

ToR 2 – Evaluate and provide recommendations on the survey method used to estimate the abundances and distributions of bocaccio, cowcod, vermillion/sunset, bank and other rockfishes in the SCB, and associated sources of uncertainty. Recommend alternative methods or modifications to the proposed methods, or both, during the panel meeting. Recommendations and requests to FRD for additional or revised analyses during the panel meeting must be clear, explicit, and in writing. Comment on the degree to which the survey results describe and quantify the distributions and abundances of rockfishes, and the uncertainty in those estimates. Confidence intervals of survey estimates could affect management decisions, and should be considered in the report.

ToR 3 – Evaluate and provide recommendations for the application of these methods for their utility in stock assessment models and for their ability to monitor trends at the population level for multiple rockfish species. Survey methods or results that have a flawed technical basis, or are questionable on other grounds, should be identified so they may be excluded from the set upon which stock assessments and other management advice is to be developed.

ToR 4 – Evaluate the effectiveness of the survey methods for detecting the appropriate spatial scale and seasonal timing for annually estimating stock abundances.

ToR 5 – Decide through Panel discussions if the ToRs and goals of the peer review have been achieved. If agreement cannot be reached, or if any ToR cannot be accomplished for any reason, then the nature of the disagreement or the reason for not meeting all the ToR must be described in the Summary and

Reviewer's report. Describe the strengths and weaknesses of the review process and Panel recommendations.

Appendix 3: Review Panel Agenda

Panel Review of The Collaborative Optical–Acoustic Survey Technique (COAST) for Surveying Rockfishes

15-17 February 2012

Day 1

0.0 Orientation (Dorn/DeVore) (1/2 hr)
1.0 Overview of rockfish biology, habitat, behavior (Butler) (1 /2 hr)
2.0 Overview of rockfish sampling, assessment, and management (Butler) (1/2 hr)
3.0 Overview of optical surveys for (Butler) (1 1/2hr)
- 3.1 Optical sampling devices and platforms
  - 3.1.1 Video, still, stereo, high-definition cameras
  - 3.1.2 Divers, submarines, AUVs, and ROVs
- 3.2 Sampling, classifying, and mapping seabed habitats of rockfishes
- 3.3 Estimating species mixtures and their sizes
- 3.4 Estimating biomasses and distributions of rockfishes, by species
- 3.5 Estimating systematic and random measurement and sampling errors
- 3.6 Summary of the advantages and limitations of optical sampling methods

4.0 Overview of acoustic-trawl surveys for estimating the abundances, distributions, and demographics of epi-pelagic fishes, and classifying and mapping their oceanographic habitat (Demer) (1/2 hr)
- 4.1 Acoustic sampling devices and platforms
  - 4.1.1 Multi-frequency echosounders
  - 4.1.2 Ships
- 4.2 Sampling, classifying, and mapping oceanographic habitats of epi-pelagic fishes
- 4.3 Estimating species mixtures and their sizes
- 4.4 Estimating biomasses and distributions of epi-pelagic fishes, by species
- 4.5 Estimating systematic and random measurement and sampling errors
- 4.6 Summary of the advantages and limitations of acoustic-trawl sampling methods

5.0 Description of acoustic-optical surveys for estimating the abundances, distributions, and demographics of rockfishes, and classifying and mapping their seabed habitats (Demer) (3 hr)
- 5.1 Acoustic sampling devices and platforms
  - 5.1.1 Multi-frequency echosounders
  - 5.1.2 Ships and AUVs
- 5.2 Sampling, classifying, and mapping seabed habitats of rockfishes

5.3 Estimating species mixtures and their sizes (refer to 3.3)
5.4 Estimating biomasses and distributions of rockfishes, by species
5.5 Estimating systematic and random measurement and sampling errors
5.6 Summary of the advantages and limitations of optical-trawl sampling methods

6. Panel Requests to Analytical Team on Day 1 Topics (Dorn) (1/2 hrs)

Day 2

7.0 Applications of the COAST (Collaborative Optical-Acoustic Survey Technique) (Demer) (2 1/2 hrs)
- 7.1 COAST Surveys
  - 7.1.1 2003 pilot survey
  - 7.1.2 COAST 2004 survey of the SCB
  - 7.1.3 COAST 2007 survey of the SCB
- 7.2 COAST survey estimates of rockfishes by species and strata
  - 7.2.1 Behaviors
  - 7.2.2 Distributions
  - 7.2.3 Seabed habitats
  - 7.2.4 Abundances and estimates of error

8.0 Utility of the COAST estimates for assessments of rockfishes (Demer) (1/2 hr)
- 8.1 Using estimates of rockfish behavior, demographics, distribution, and abundance, and maps of their seabed habitat
  - 8.1.1 Species for which the method is appropriate
  - 8.1.2 Scaling survey density estimates to population level
- 8.2 Future work

9.0 Panel Requests to Analytical Team on Day 2 Topics (Dorn) (1/2 hrs)

10.0 Review Work Assignments and start drafting report (Dorn) (4 hrs)

Day 3:

11.0 Review Work Assignments and continue drafting report (Dorn) (8 hrs)

Appendix IV: Background Documents

List of background documents reviewed:

1) David A. Demer (ed). 2012. **2003 Survey of Rockfishes in the Southern California Bight using the Collaborative Optical–Acoustic Survey Technique COAST03**. Report of the data collection, preliminary analysis, and tentative conclusions for the COAST survey aboard CPFV *Outer Limits*, 4 November 2003 to 4 April 2004. U.S. Department of Commerce, National Oceanic & Atmospheric Administration National Marine Fisheries Service Southwest Fisheries Science Center Fisheries Research Division Advanced Survey Technologies Program 8604 La Jolla Shores Drive La Jolla, California, U.S.A. 92037. 81p.

2) David A. Demer (ed). 2012. **2004 Survey of Rockfishes in the Southern California Bight using the Collaborative Optical–Acoustic Survey Technique COAST04**. Report of the data collection, preliminary analysis, and tentative conclusions for the COAST survey aboard CPFV *Outer Limits*, 4 October 2004 through May 2005. U.S. Department of Commerce, National Oceanic & Atmospheric Administration National Marine Fisheries Service Southwest Fisheries Science Center Fisheries Research Division Advanced Survey Technologies Program 8604 La Jolla Shores Drive La Jolla, California, U.S.A. 92037. 95p.

3) David A. Demer (ed). 2012. **2007 Survey of Rockfishes in the Southern California Bight using the Collaborative Optical–Acoustic Survey Technique COAST07**. Report of the data collection, preliminary analysis, and tentative conclusions for the COAST survey aboard CPFV *Outer Limits*, 26 August to 31 October 2007. U.S. Department of Commerce, National Oceanic & Atmospheric Administration National Marine Fisheries Service Southwest Fisheries Science Center Fisheries Research Division Advanced Survey Technologies Program 8604 La Jolla Shores Drive La Jolla, California, U.S.A. 92037. 95p.

4) David A. Demer*, Juan P. Zwolinski*, George R. Cutter, Jr.*, Kyle A. Byers*, Kevin L. Stierhoff*, David Murfin*, Josiah S. Renfree*, Scott Mau*, Thomas Steve Sessions*, Ken Franke, and John L. Butler. 2012. The Collaborative Optical-Acoustic Survey Technique (COAST) for estimating the abundances and distributions of rockfishes, and mapping their seabed habitats. National Oceanic and Atmospheric Administration, Southwest

Fisheries Science Center, La Jolla Shores Drive, La Jolla, CA, 92037. 41p.

5) NOAA. 2012. Terms of Reference for the Methodology review process for groundfish and coastal pelagic species. Pacific Fishery Management Council. Draft January 20, 2012. 11p.

6) Mello, L.S.G. and G.A. Rose. 2009. The acoustic dead zone: theoretical vs. empirical estimates, and its effect on density measurements of semi-demersal fish. – ICES Journal of Marine Science, 66: 1364–1369.

7) Thomas E. Laidig, Lisa M. Krigsman, and Mary M. Yoklavich. 2012 – (Draft). Reactions of fishes to the underwater survey tools the *Delta* submersible and a Phantom remotely operated vehicle. Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, 110 Shaffer Road, Santa Cruz, CA 95060, USA. 28p.

8) Milton S. Love, Mary Yoklavich, and Donna M. Schroeder. 2009. Demersal fish assemblages in the Southern California Bight based on visual surveys in deep water. Environ Biol Fish (2009) 84:55–68. 14p.

9) Ona E. and Mitson R. B. 1996. Acoustic sampling and signal processing near the seabed: the deadzone revisited. – ICES Journal of Marine Science, 53: 677–690.

10) Ruben Patel, Geir Pedersen, and Egil Ona. 2009. Inferring the acoustic dead-zone volume by split-beam echo sounder with narrow-beam transducer on a noninertial platform. *Acoustical Society of America.* DOI: 10.1121/1.3050325. 698-705.

11) Rooper. 2012. Untitled paper in press. 2012. Comparing ROV, trawl and drop camera observations.

12) Christopher D. Wilson, Anne B. Hollowed, Michiyo Shima, Paul Walline, and Sarah Stienessen. 2003. Interactions Between Commercial Fishing and Walleye Pollock. Alaska Fishery Research Bulletin. Vol. 10 No. 1, 59-80.

13) Mary M. Yoklavich, H. Gary Greene, Gregor M. Cailliet, Deidre E. Sullivan, Robert N. Lea, and Milton S. Love. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: an example of a natural refuge Fish. Bull. 98:625–641.

Appendix V: List of Participants

Methodology Review Panel Members:

Martin Dorn (Chair), Scientific and Statistical Committee (SSC), NMFS, Alaska Fisheries Science Center
Luiz Mello, Center for Independent Experts
Gary Melvin, Center for Independent Experts
André Punt, SSC, University of Washington
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Noelle, Bowim, NMFS, SWFSC
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Ken Franke, SAC
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